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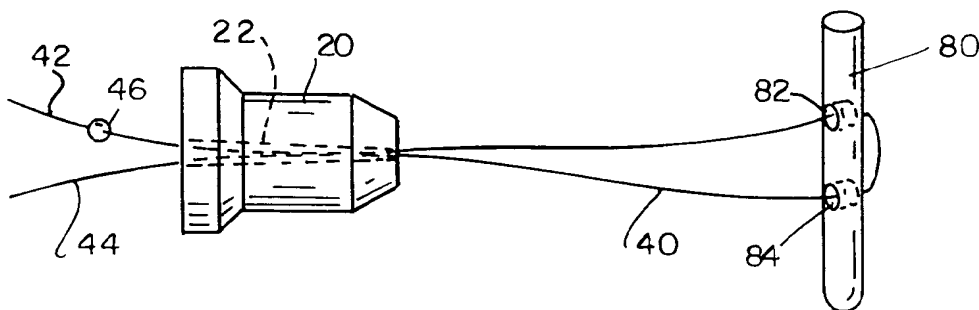
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(54) **Suture locking device**

(57) A device for locking a suture in place comprises an anchor having a front section and a rear section. A

cannula extends through the front and rear sections through which the suture extends, and a locking mechanism locks the suture within the cannula.



*FIG. 1*

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## Description

[0001] The present invention relates to a device for locking a suture in vivo, more particularly to a device for locking a suture in vivo without the need for tying knots once the suture is placed within tissue. The present invention also relates to a method for using such a device to approximate tissue and to lock the suture in place.

[0002] It is known in the art to approximate damaged or torn tissue by use of a suture. In many instances, the suture is looped through tissue, and the two ends are then secured together. Prior art methods for securing a suture include tying knots. Other methods include providing a filament which has various protruding portions and securing the filament against one of those protruding portions, for example as disclosed in US-5520691. Other known methods include compressing the suture between a cylinder/piston wall interface, for example as disclosed in US-5630824. Such sutures may be used to approximate damage in soft tissue or to attach soft tissue to bone.

[0003] The present invention provides a suture locking device which relies on frictional forces. In one embodiment, a suture is passed through an anchor having a tapered or stepped cannula. The suture may then be passed through tissue, through or around a second anchor located on the opposite side of the defect, and looped back through the cannula. One end of the suture may be provided with a knot or bead. As the surgeon pulls on the second end, the knot or bead enters the cannula, pulls the two anchors toward each other, then both strands wedge tightly in the cannula. In an alternative embodiment, instead of a knot or bead, a slip knot is provided on the first end. The second end may be threaded through the slip knot. Again, as the surgeon pulls on the second end, the knot will enter the tapered or stepped cannula, pull the two anchors together, and wedge both strands tightly within the cannula.

[0004] In another embodiment of this invention, a locking ring may be used to secure the sutures to the anchor. The anchor may be provided with a split section and the suture would pass through this split section. The locking ring may be of either the push-type or the pull-type, and when engaged, the locking ring would force the portions of the split section together, thus wedging the split section together and locking the suture strands in place. The split section may be provided with teeth to grip the suture better.

[0005] In another embodiment, the suture may be secured with a snap groove. As with the locking ring arrangement, the anchor would be provided with a split section. A tooth on one section may be sized and shaped to mate with a groove on the other section. When the tooth is snapped into the groove, the suture strands would be locked into place.

[0006] An additional embodiment may employ a wedge design. In such a design, the anchor may be provided with a cylindrical cannula, and a wedge would be

provided to fit tightly within the cannula. The wedge itself may be partially cannulated to aid in insertion, but the suture would also, in part, pass along the exterior of the wedge, so that frictional forces would secure the suture between the wedge and the inside of the cannula, in order to lock the suture in place.

[0007] Alternatively, the suture locking device may comprise laminated sheets. Slits in the laminated sheets would allow the suture to pass in one direction with little resistance. However, the sheets may be designed to lock on the suture when the suture is pulled in the reverse direction.

[0008] Some embodiments of the present invention can be used in applications in which the suture is looped through tissue, and two ends of the suture must be secured. Other embodiments can be used in which one strand is secured at each end. It will be understood that the invention may be employed in situations involving a single strand or with multiple suture or filament strands, and that the two ends of the suture need not be secured within a single locking mechanism.

[0009] The anchor may be made of biocompatible material such as stainless steel, titanium, cobalt chrome, and polyethylene. Preferably, biodegradable materials may also be used, including poly lactic acid and poly lactic-glycolic acid. Other biodegradable materials are known, for example as disclosed in US-4976715. The suture may be made of known resorbable or non-resorbable materials.

[0010] Embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 is a cross-sectional view of a locking device of this invention, in which the locking device comprises an anchor with a tapered cannula and a suture with a bead, shown in combination with a second anchor;

Fig. 2 is a cross-sectional view of the anchor of Fig. 1, with the suture in locked position;

Fig. 3 is similar to Fig. 2, except that the cannula is stepped rather than tapered;

Fig. 4 is similar to Fig. 1, except that a slip knot replaces the bead;

Fig. 5 is a cross-sectional view of another embodiment of this invention, in which the suture locking device comprises a pull locking ring in combination with a cannulated anchor;

Fig. 6 is similar to Fig. 5, except showing the device in a locked position;

Fig. 7 is similar to Fig. 5, except showing a device with a push locking ring;

Fig. 8 is similar to Fig. 7, except showing the device in a locked position;

Fig. 9 is a cross-sectional view of an embodiment of this invention which employs a snap lock design;

Fig. 10 is a cross-sectional view of still another embodiment of this invention which employs a wedge

design;

Fig. 11 is a perspective view of an additional embodiment of this invention, employing a laminated sheet design;

Fig. 12 is a cross-sectional view of Fig. 11, along line 12-12;

Fig. 13 is a cross-sectional view of a meniscus of a knee, showing a defect approximated by a suture which is locked into position by using two locking devices of Fig. 11.

**[0011]** Referring to the drawings, Fig. 1 shows generally a suture locking device of this invention in a combination as the device may be employed. In the embodiment shown in Fig. 1, a suture 40 passes through a cannula 22 in an anchor 20. The suture loops through a second anchor 80, and then returns through cannula 22. In use, anchor 20 and second anchor 80 may be located on opposite sides of a soft tissue defect (not shown), and suture 40 may be used to pull the defect together. Alternatively, second anchor 80 may be located within or beyond a bone (not shown), and anchor 20 may be used to attach soft tissue to the bone. Other applications are also possible.

**[0012]** As shown, second anchor 80 is provided with two holes 82, 84. Suture 40 loops through first hole 82 and returns through second hole 84. Alternatively, second anchor 80 may be provided with a singular cannulation lengthwise with the suture 40 extending through it, or the second anchor 80 may be provided without any holes, and the suture 40 may merely loop over second anchor 80. In some situations, a second anchor may not be necessary, and suture 40 simply loops over or through tissue.

**[0013]** Also as shown, the anchor 20 is configured to bury partially or totally into tissue, for use in tissue repair where interference with the tissue surface is not desirable. This may be desirable for use on surfaces such as the inner surface of the meniscus of the knee. However, as illustrated in Figs. 10 - 13, anchors which are configured to abut, without entering, tissue is also within the scope of this invention. The combination illustrated in Fig. 1 is meant merely as an example of the type of suturing which may be locked with the suture locking device of this invention.

**[0014]** Still referring to Fig. 1, suture 40 is provided with a first end 42 and a second end 44. First end 42 may be provided with a bead 46, and the cannula 22 may be tapered. As the surgeon pulls on the second end 44 of suture 40, the bead 46 enters the cannula 22. With continued pulling, the bead 46 pulls anchor 20 toward second anchor 80, for example, to close a defect in tissue or to secure soft tissue to a bone. When anchor 20 is fully seated, bead 46 wedges into cannula 22, and secures the second end 44 within the cannula 22 as well.

**[0015]** Fig. 2 illustrates the anchor 20 of Fig. 1 after the suture 40 has been pulled tight and locked into

place. Fig. 3 illustrates an alternative embodiment wherein the cannula 22 is stepped, rather than tapered. As with the embodiment illustrated in Fig. 2, when suture 40 is pulled tight, the bead 46 locks the suture 40 in place. Bead 46 may be permanently affixed to suture 40 in any number of ways. Alternatively, suture 40 may be manufactured with bead 46 as a protuberance integral with the suture filament. Also, bead 46 may be a knot in suture 40 of sufficient size.

**[0016]** Another embodiment is illustrated in Fig. 4. The first end 42 of suture 40 is provided in a slip knot 48. As with the embodiment shown in Fig. 1, the anchor 20 may be provided with a cannula 22 which is tapered or stepped. The second end 44 may be fed through loop 49 of slip knot 48, and the loop 49 may be tensioned slightly. As the surgeon pulls on the second end 44, the knot 48 will travel distally along the second end 44, until the knot 48 begins to push the anchor 20 toward the second anchor 80. As with the bead 46 of Fig. 1, the knot 48 wedges in cannula 22, locking the suture in place.

**[0017]** Figs. 5 to 8 relate to embodiments which employ a locking ring. Figs. 5 and 6 involve a pull locking ring with Fig. 5 illustrating the open position and Fig. 6 illustrating the locked position. As illustrated, anchor 20 is provided with cannula 22. Rear section 24 of anchor 20 may be split into first and second rear portions 26, 28, which define split gap 30. An annular locking ring 70 is provided around middle section 25. Once anchor 20 and suture 40 are properly positioned, locking ring 70 may be pulled in the direction away from front 23 and toward rear 24 of anchor 20. First and second rear portions 26, 28 compress together, thus locking suture 40 within. Teeth 32 may be provided to insure secure gripping of suture 40. As illustrated in Fig. 6, a groove 72 on locking ring 70 may seat on tip 29 to secure locking ring 70 in place.

**[0018]** Referring specifically to Fig. 5, as illustrated, in the open position locking ring 70 sits between front section 23 and rear section 24. An insertion tool (not shown) may engage a recess or protuberance (not shown) in rear surface 74 of the locking ring 70, in order to pull locking ring 70 to the closed position, as illustrated in Fig. 6. Also, because middle section 25 of anchor 20 provides a recess in which locking ring 70 sits while in the open position, locking ring 70 need not be physically connected to anchor 20. Alternatively, a frangible portion (not shown) may be used to secure locking ring 70 to anchor 20. The frangible portion would be broken as locking ring 70 is pulled back to the closed position.

**[0019]** Figs. 7 and 8 illustrate an embodiment of a suture locking device employing a push locking ring. Fig. 7 illustrates the push locking ring 60 with the device in the open position. As with the embodiment shown in Figs. 5 and 6, anchor 20 may be provided with a rear section 24 which has been split into first and second rear portions 26, 28, defining slit gap 30. A locking ring 60 is disposed around rear section 24. When locking ring 60

is pushed toward the front section 23 of anchor 20, the locking ring compresses rear portions 26 and 28 together, locking the suture 40 between them. As with the pull locking ring embodiment illustrated in Figs. 5 and 6, the anchor 20 may be provided with teeth 32, in order to better secure suture 40. Once locking ring 60 is in the locked position, lip 34 may lock edge 62 in place and restrain locking ring 60 from moving back to the open position. As illustrated, edge 62 is recessed from rear surface 64. However, edge 62 may protrude from or be contiguous with rear surface 64.

**[0020]** Still referring to Figs. 7 and 8, rear surface 64 of locking ring 60 may be provided with a recess (not shown) for use with an insertion tool (not shown). Also, locking ring 60 may be connected to anchor 20 by a frangible portion 66. When force is placed on locking ring 60, the frangible portion 66 would break, and locking ring 60 would slip into the locked position shown in Fig. 8. An alternative location for the frangible portion is illustrated as frangible portion 66a, although many other locations are possible. Alternatively, locking ring 60 need not be physically connected to anchor 20 and may be inserted simply by pushing it along suture 40.

**[0021]** Fig. 9 illustrates an embodiment of this invention which employs a snap groove. As with the locking ring embodiments, rear section 24 of anchor 20 is split into first and second portions 26, 28, defining split groove 30. A tooth 36 is provided on first portion 26, while a matching groove 37 is provided on second portion 28. Suture 40 which has been inserted through cannula 22, also extends between tooth 36 and groove 37. When tooth 36 is snapped into groove 37, suture 40 is captured between them and becomes locked into place.

**[0022]** A wedge design may be used, as illustrated in Fig. 10. In this embodiment, anchor 20 is provided with cannula 22. A wedge 50 may be shaped to fit snugly within cannula 22. Wedge 50 may be partially cannulated, as illustrated with cannulae 52. As illustrated, suture 40 may be threaded through cannula 22 of anchor 20 and then through cannulae 52 of wedge 50. As illustrated, suture 40 also passes over arch 54. With tension on suture 40, wedge 50 may be pushed into cannula 22. Suture 40 then becomes locked between arch 54 and the inner wall of cannula 22. While the illustrated cannula and wedge are cylindrical, it will be understood that other shapes may be used.

**[0023]** Still referring to Fig. 10, the anchor 20 as illustrated may be used in applications where front section 23 of anchor 20 is to remain flush with the tissue surface. However, it is understood that a wedge suture locking device may be used in various applications with various anchor designs.

**[0024]** Figs. 11 and 12 illustrate another embodiment of a locking device of this invention. Locking ring 90 is constructed from a series of laminated sheets 92. The laminated sheets may be bonded or welded together along the circumference 95 of locking ring 90. Slits 93 may be provided through each of the laminated sheets

92. An aperture 94 is defined as the intersection of slits 93. Aperture 94 allows suture 40 to pass through locking ring 90. As can be seen in Fig. 12, the laminated sheets are constructed such that if suture 40 is pulled in the direction indicated by the arrow, suture 40 may pass freely with little resistance. However, if suture 40 is pulled in the opposite direction, slits 93 close as laminated sheets 92 start bending back upon themselves. Thus, suture 40 is locked into position.

**[0025]** Fig. 13 illustrates two locking rings of Figs. 11 and 12 which may be used to repair a defect 101 in a meniscus 100. As illustrated, locking ring 90a is located at the inner surface 102 of meniscus 100, while locking ring 90b is located at the outer surface 103 of meniscus 100. Locking rings 90a and 90b secure suture 40 in place, thereby approximating the defect 101. It should be understood that Fig. 13 is illustrative of just one example of the present invention. Any of the embodiments could be used to approximate such a defect. The various embodiments of this invention may be used to secure one or multiple sutures in a wide variety of uses.

**[0026]** It will be apparent that features of the present invention include, singly or in combination:

1. A suture locking device which secures one or more suture strands.
2. Such a device in which a bead or knot is used to secure the suture within a cannula. The cannula may be tapered or stepped.
3. Such a device in which a slip knot is used to secure the suture within a cannula. The cannula may be tapered or stepped.
4. Such a device in which the suture is secured by use of a locking ring. The locking ring may be a push locking ring or it may be a pull locking ring.
5. Such a device in which the suture is secured by use of a snap groove.
6. Such a device in which the suture is secured within a cannula with a wedge. The wedge is sized and shaped to fit snugly within the cannula. The wedge may be partially cannulated to aid in insertion.
7. Such a device in which the suture is secured with a locking ring comprised of laminated strips. The laminated strips may be provided with slits, and may be positioned and shaped to allow the suture to be pulled in one direction, but to lock down and prevent the suture from moving in the opposite direction.

## Claims

1. A device for locking a suture in place, comprising an anchor having a cannula through which the suture extends; and a locking mechanism for locking the suture within the cannula.
2. A device as claimed in claim 1, in which the cannula is tapered.

3. A device as claimed in claim 2, in which the suture comprises a first end and a second end and wherein the first and second ends pass through the cannula, and the locking mechanism comprises a bead provided at the first end of the suture, the bead sized to wedge within the cannula when tension is applied to the second end, thereby locking the first and second ends of the suture in the cannula. 5
4. A device as claimed in claim 2, in which the suture comprises a first end and a second end and wherein the first and second ends pass through the cannula, and the locking mechanism comprises a knot formed at the first end of the suture, the knot sized to wedge within the cannula, thereby locking the first and second ends of the suture in the cannula. 10 15
5. A device as claimed in claim 1, in which the cannula is stepped, the suture comprises a first end and a second end and wherein the first and second ends pass through the cannula, and the locking mechanism comprises a bead provided at the first end of the suture, the bead sized to wedge within the cannula, thereby locking the first and second ends of the suture in the cannula. 20 25
6. A device as claimed in claim 2, in which the anchor comprises a rear edge and a front edge, the suture comprises a first end and a second end, and the locking mechanism comprises a slip knot provided at the first end of the suture, the suture extending through the cannula of the anchor from the rear edge of the anchor to the front edge of the anchor, through a portion of tissue, and extending back through the cannula from the front edge to the rear edge, the second end passing through the slip knot, whereby tension on the second end of the suture causes the slip knot to travel distally toward the front edge of the anchor until the slip knot tightens on the second end locking the first and second ends in place within the cannula. 30 35 40
7. A device as claimed in claim 1, in which the locking mechanism comprises a wedge shaped to fit snugly within the cannula to secure the suture therein. 45
8. A device as claimed in claim 7, in which the cannula of the anchor defines an inside wall, the wedge comprises an outside surface, a first part, a second part, and a third part, the first and third parts being cannulated, whereby threading the suture through the cannulations of the first and third parts causes the suture to extend along the outside surface adjacent to the second part, and insertion of the threaded wedge into the cannula of the anchor secures the suture between the inside wall and the outside surface adjacent to the second part. 50 55
9. A device as claimed in claim 1, in which the locking mechanism comprises a locking ring.
10. A device as claimed in claim 9, in which the locking ring comprises a series of laminated sheets, the series of laminated sheets having an aperture that allows the suture to pass when pulled in a first direction, but locks the suture in place when the suture is pulled in an opposite direction.
11. A device for locking a suture in place, which comprises an anchor having a front section and a rear section, a cannula extending through the front and rear sections through which the suture extends, and a locking mechanism for locking the suture within the cannula in the rear section of the anchor.
12. A device as claimed in claim 11, in which the locking mechanism is a locking ring.
13. A device as claimed in claim 12, in which the rear section comprises a split gap dividing a portion of the cannula, and activation of the locking ring closes the split gap, thereby securing the suture within the cannula.
14. A device as claimed in claim 13, in which the locking ring is a pull locking ring or a push locking ring.
15. A device as claimed in claim 11, in which the locking mechanism comprises a snap groove.
16. A suture locking kit for locking a suture in place, comprising a suture, an anchor having a front edge and a rear edge, the anchor having a cannula extending from the front edge to the rear edge, and a locking mechanism, in which  
the suture comprises a first end and a second end, and can extend through the cannula of the anchor from the rear edge to the front edge, through a portion of tissue, and extending back through the cannula from the front edge to the rear edge, the second end protruding from the rear edge of the suture; and  
the locking mechanism comprises a bead located at the first end of the suture, the bead sized to fit snugly within a portion of the cannula; so that pulling the second end of the suture causes the bead to travel toward the front edge of the anchor and to wedge within the portion of the cannula, thereby locking the suture in place.
17. A kit as claimed in claim 16, in which the cannula is tapered to have a diameter at the front edge that is smaller than a diameter at the rear edge.

18. A kit as claimed in claim 16, in which the cannula is stepped to have a diameter at the front edge that is smaller than a diameter at the rear edge.

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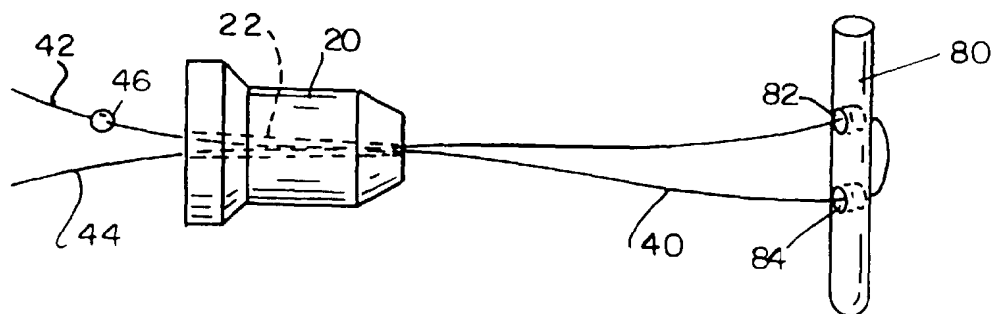


FIG 1

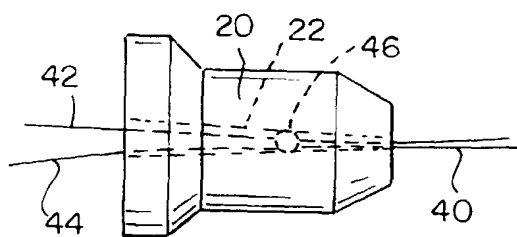


FIG 2

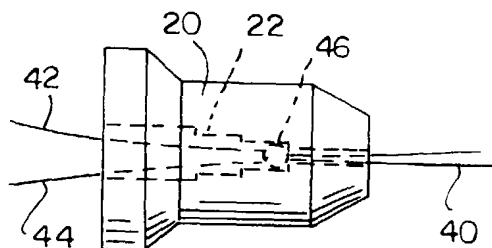


FIG 3

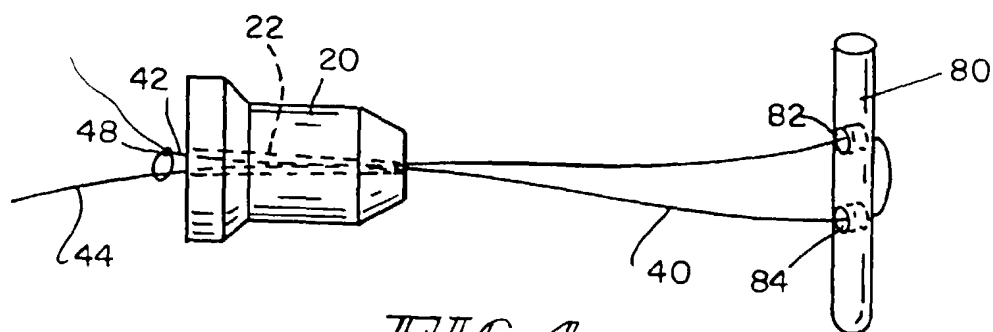


FIG 4

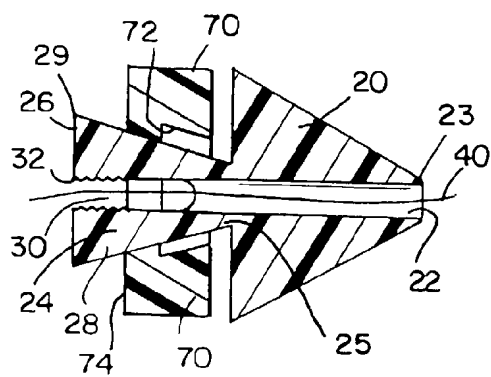


FIG. 5

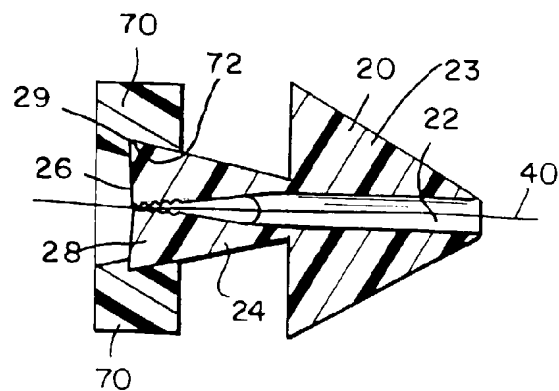


FIG. 6

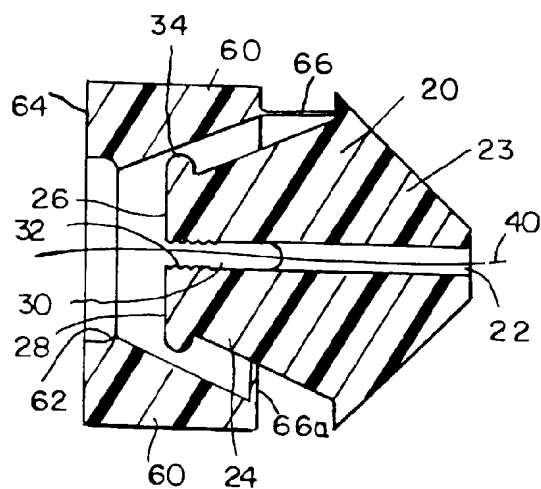


FIG. 7

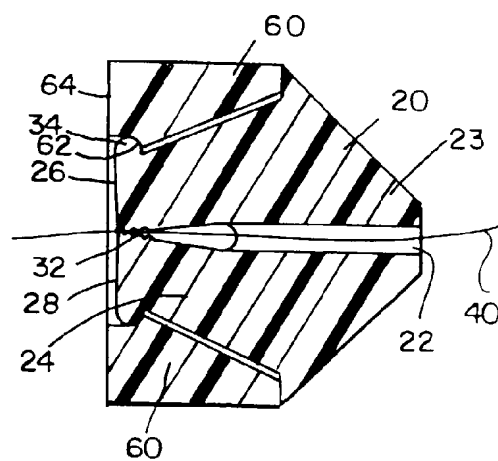
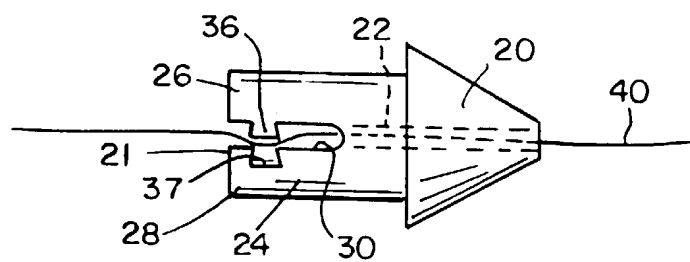
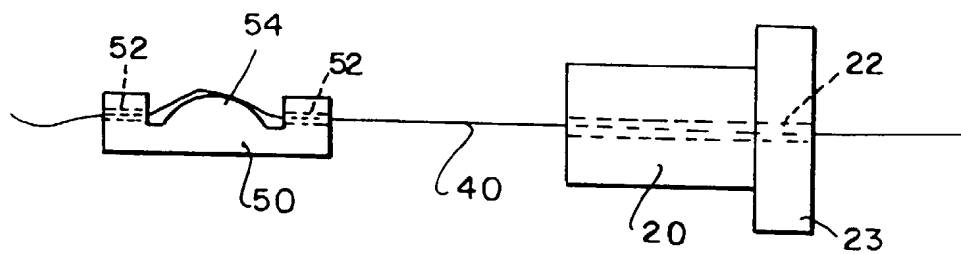


FIG. 8





*FIG. 9*



*FIG. 10*

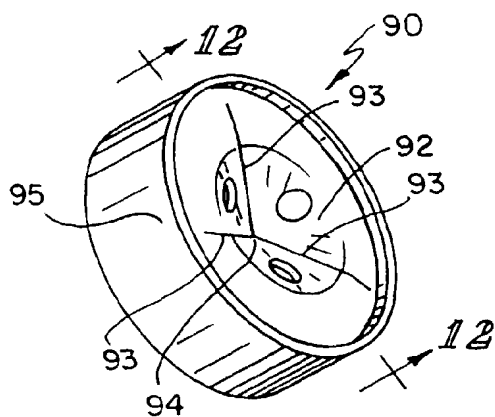


FIG 11

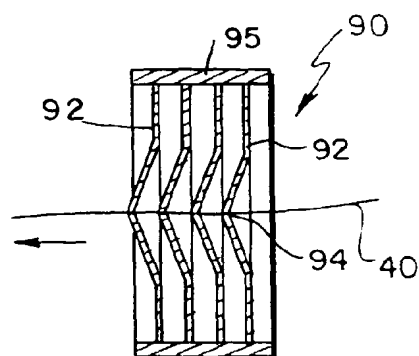


FIG 12

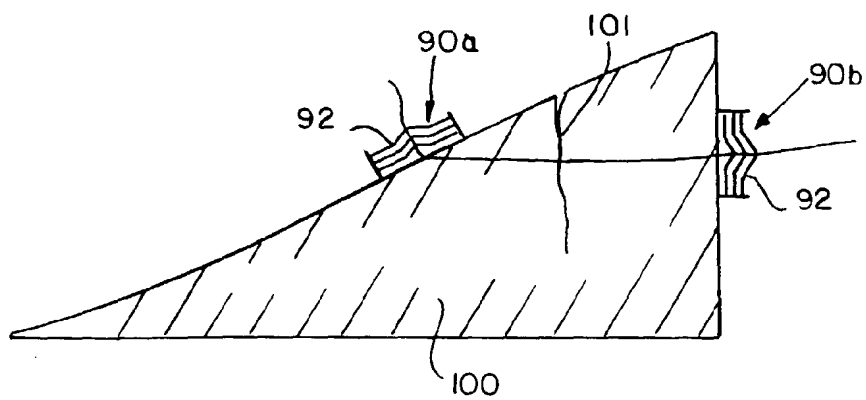


FIG 13